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CARDIOELECTROMAGNETIC TREATMENT

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] This invention generally relates to cardiology and, more particularly, to non-invasive and invasive cardio-electromagnetic therapy.

2. DESCRIPTION OF THE BACKGROUND

[0002] Intrinsic rhythmicity is a well-established cardiac property. Intrinsic rhythmicity is the heart's ability to initiate its own heart rate, rhythm, and conductivity without nervous innervation. Even though the heart can initiate its own heart rate, rhythm, and conductivity, the autonomic nervous system is known to strongly influence heart rate, rhythm, and conductivity. The autonomic nervous system, in fact, has a great influence on other cardiac properties such as contractility (e.g., heart pump strength) and refractoriness (e.g., excitable readiness).

[0003] The autonomic nervous system has two components. One component, the parasympathetic nervous system, can cause slowing of the heart rate and slowing of atrio-ventricular (A-V) conduction in the heart. The A-V conduction rate is slowed when the parasympathetic nervous system releases acetylcholine at the atrio-ventricular node. The heart rate is slowed when the parasympathetic nervous system releases acetylcholine at the

nerve terminals at the sino-atrial node. The sino-atrial node is considered the heart's primary "pacemaker."

[0004] The other component of the autonomic nervous system is the sympathetic nervous system. The sympathetic nervous system, conversely, causes speeding of the heart rate, speeding of the A-V conduction rate, and constriction of blood vessels. The sympathetic nervous system releases neurotransmitters, such as epinephrine and norepinephrine, to speed heart rate and A-V conduction. The sympathetic nervous system is also known to cause an increase in the force of contraction of the heart muscle. The neurotransmitters epinephrine and norepinephrine have also been implicated in the irregular heart rhythm called arrhythmias. Arhythmias is an irregularity of the heart rate arising from either the atria or the ventricles.

[0005] Because the autonomic nervous system is known to influence heart properties, research has focused on stimulating the autonomic nervous system. One research avenue shows that electrical stimulation of the autonomic nervous system causes the release of neurotransmitters. These neurotransmitters, as mentioned above, affect heart rate, rhythm, conductivity, and contractility. This electrical stimulation has, however, always required surgical dissection of the parasympathetic and sympathetic nerves. Surgical dissection of nerve tissue is not acceptable or practical for clinical studies and clinical purposes.

[0006] Another research avenue has been chemical stimulation. Researchers have chemically synthesized the neurotransmitters that affect heart rate, rhythm, conductivity, and contractility. This chemical stimulation has proven useful in modulating cardiac properties in clinical circumstances. "Beta-blockers" such as propanolol, for example, have been used as sympathetic nerve blocking agents. These beta-blockers have proven invaluable in controlling abnormalities of the heart's rhythm, rate, and conduction.

[0007] Chemical stimulation, however, is approached with caution. The effects of chemical stimulation are not completely understood. Chemically synthesized neurotransmitters, or similar agents, are very technologically new and the long-term affects are unknown. A further problem is that patients are often found to become non-compliant, i.e., they stop their medication or their compliance is irregular.

[0008] Accordingly, there is a need to stimulate the autonomic nervous system that does not require surgical dissection of nerve tissue, which is acceptable to clinical subjects, and is cost effective to administer. These advantages and other advantages are provided by the system and method described herein, and numerous disadvantages of existing techniques are avoided.

SUMMARY OF THE INVENTION

[0009] In accordance with one aspect of the invention, there is provided a method of treatment or prophylaxis of a disease state or a condition. An organism is subjected to electromagnetic field having an electromagnetic flux density from about 5 X 10^{-6} gauss to about 1 X 10^{-12} gauss and a frequency of between about zero and about 140 Hertz. The electromagnetic field is applied therapeutically to treat or prevent cardiac diseases and conditions. The diseased state or condition may include elevated heart rate, irregular heart rate, elevated blood pressure, cardiovascular failure, blood clots, atrial fibrillation, ventricular fibrillation, atrioventicular blockage, diseased heart valves, enlarged heart, circulatory blockage, coronary insufficiencies, and ischemia.

[0010] In a more specific aspect, the magnetic flux density of the field is calculated using the formula $mc^2 = Bvlq$, where B is the magnetic flux density, m is the mass of one or more targets, c is the speed of light, v is the inertial velocity of the mass, l is the length of the organism to which the field will be applied, and q is a unity of charge.

[0011] Preferably, the electromagnetic field is administered to affect the autonomic nervous system. In one aspect, the electromagnetic radiation is administered in a range between about 2 to about 3.4 X 10^{-8} gauss and a frequency between about 0 to about 28 Hertz to affect the parasympathetic nervous system. In an alternative aspect, the electromagnetic radiation is administered in a range between about 7.6 X 10^{-8} to about 1 X 10^{-6} gauss at a frequency from about 0 to about 28 Hertz to affect the sympathetic nervous system.

[0012] The organism may be subjected to the electromagnetic field by either placing the organism inside an external apparatus for generating the electromagnetic field. Alternatively, the organism may be subjected to the electromagnetic radiation by implanting a device for generating the electromagnetic field directly into the organism. The device is implanted in proximity to the organ to which treatment is targeted. Thus, the treatment may be administered either non- invasively or invasively.

[0013] In another aspect of the invention, a device invasively administers an electromagnetic field in an organism. The device has at least one inductor for emitting electromagnetic energy, which has a magnetic flux density from about 5 X 10^{-6} gauss to about 1 X 10^{-12} gauss and a frequency between 0 and 140 Hertz. The device also has a means for implanting the inductor into the organism. The inductor may be either a Helmholtz coil, a solenoid coil, or a saddle coil. The means for implanting may be a catheter or a stent. One of ordinary skill in the art would understand that other means for implanting the inductor are possible and easily interchanged with a catheter or stent, for example, any medical device having a receptacle for the inductor such that the inductor may be implanted into an organism.

[0014] In a more specific aspect, the device has a first wire and a second wire connected to the ends of the inductor, and a signal generator for generating an electric signal through the first and second wires and an attenuator for attenuating the signal. The attenuator and the signal generator may not be implanted into the organism.

[0015] In another more specific aspect, the device has a balloon attached to the first end of the catheter tube, which is inflatable and deflatable in response to fluid pressure within the catheter tube. The inductor is located within the balloon. Preferably, the inductor expands and contracts correspondingly with the balloon inflation and deflation.

[0016] In yet another aspect, a device invasively administers an electromagnetic field in an organism. The device has at least one solenoid for emitting the electromagnetic field, which has a magnetic flux density from about 5 X 10^{-6} gauss to about 1 X 10^{-12} gauss and a frequency between about 0 and about 140 Hertz. A capacitor is operatively connected to the solenoid. The device also has a means for implanting the solenoid and the capacitor into the organism, and a means for inducing an electric current in the solenoid. The means for

implanting may be a stent. One of ordinary skill in the art would understand that other means for implanting the inductor are possible and easily interchanged with a stent, for example, a catheter or other medical device having a receptacle for the inductor.

[0017] In a more specific aspect, the means for inducing the electric current in the solenoid is a catheter that is removably insertable into the solenoid. A second solenoid coil is attached to the catheter, which is also removeably insertable into the solenoid. A means for generating an electric current through the second solenoid coil is provided. The electric current in the second solenoid induces an electric current in the first solenoid coil. Preferably the means for inducing the electric current is a first wire attached to a first end of the second solenoid coil; a second wire attached to a second end of the second solenoid coil, an attenuator operatively connected to the first and second wires, and a signal generator operatively connected to the first and second wires. The signal generator generates a signal, which is attenuated by the attenuator and carried along the first and second wires. The signal generator and the attenuator are not implanted in the organism.

[0018] In an alternative aspect, the means for inducing the electric current in the solenoid is an electromagnetic field generator that is external to the organism. In one specific aspect, the electromagnetic field generator may be a Helmholtz coil external to the organism. The organism in which the solenoid has been implanted is placed inside of the Helmholtz coil such that a current is induced in the solenoid coil. An attenuator is connected to the Helmholtz coil and a signal generator is connected to the attenuator for generating a signal to the Helmholtz coil. In an alternative specific aspect, the electromagnetic field generator is a second solenoid external to the organism. The organism in which the first solenoid has been implanted is placed inside of the second solenoid such that a current is induced in the first solenoid coil. An attenuator is operatively connected to the second solenoid coil and a signal generator is operatively connected to the attenuator for generating a signal to the second solenoid coil.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] These and other features, aspects, and advantages of the present invention will be better understood when the following Detailed Description is read with reference to the accompanying drawings, wherein:

[0020] FIG. 1 shows a system used to treat persons or mammals, with extremely low frequency electromagnetic fields;

[0021] FIGS. 2 and 3 are graphs showing the results of the very low frequency treatment;

[0022] FIG. 4 is a graph showing the effects of the treatment on atrioventricular conduction measured as A-H intervals;

[0023] FIG. 5 is an isometric view of a catheter for invasively administering the very low frequency electromagnetic treatment;

[0024] FIG. 6 includes two partial views of an alternative embodiment of the catheter shown in FIG. 5;

[0025] FIG. 7 is an isometric view of another alternative embodiment of a catheter for invasively administering the very low frequency electromagnetic treatment;

[0026] FIG. 8 shows an implantable device for invasively administering the very low frequency electromagnetic treatment;

[0027] FIG. 9 shows an alternative application for an implantable device for invasively administering the very low frequency electromagnetic treatment;

[0028] FIG. 10 shows still another alternative embodiment for invasively administering electromagnetic treatment referred to herein as a stent coil. A signal is induced in the stent coil by a catheter coil; and

[0029] FIG. 11 shows the stent coil configured such that a signal is induced in the stent coil by an external coil arrangement.

DETAILED DESCRIPTION

[0030] FIG. 1 shows a system 25 used to treat persons or other organisms, with extremely low frequency electromagnetic fields. By "low frequency electromagnetic fields" is meant less than about 5×10^{-6} gauss. A signal generator 27 generates an input signal, typically of a

voltage ranging from about 10^{-3} to about 10^{-12} volts, or about 10^{-5} to about 10^{-12} amperes having an Electric Field strength of about 10^{-3} volts per centimeter to about 10^{-12} volts per centimeter. The input signal transmitted along a first wire 29 and is received by a voltage attenuator 31. The voltage attenuator 31 attenuates the signal. The attenuated signal is transmitted along a second wire 33 and is received by at least one inductor. By the term inductor is meant an electronic component that stores energy in the form of a magnetic field. An inductor may be a wire loop or coil in a given shape to approximate unidirectional current by inertial – electromagnetic induction. The inductor could also be a magnet. The inductor may or may not include a dielectric material. As would be understood by one of ordinary skill in the art, the relationship between the magnetic flux ("B"), the magnetic constant of the dielectric (μ_0) and the magnetic field strength (H) is an example of an inductor is shown in FIG. 1 as a first coil 35 arranged in series with a second coil 37. The attenuated signal, after flowing through the inductor, returns to the signal generator 27 along a third wire 39 to complete a circuit.

[0031] As would be understood by one of ordinary skill in the art, current flowing through a wire is widely known to produce magnetic flux density. *See* DAVID K. CHENG, FIELD AND WAVE ELECTROMAGNETICS 225-50 (1983). Thus, many types of wire arrangements produce a magnetic flux density and can be substituted for the first and second coils 35 and 37 shown in FIG. 1. The first and second coils 35 and 37 are in an exemplary form, a Helmholtz coil. A Helmholtz coil is a pair of flat coils having equal numbers of turns and equal diameters arranged with a common axis and connected in series such that the electrical current flows in the same direction around both coils such that a magnet field is produced. Thus, the first and second coils 35 and 37 depicted in FIG. 1 may have several turns of wire. A Helmholtz coil produces a more uniform magnetic field than a single coil. Examples of other wire arrangements capable of producing magnetic fields include solenoid coils, saddle coils, toroidal, and poloidal coils. Solenoid coils are a wound coil arrangement of wire carrying an electric current for producing a magnetic field. A saddle coil is a pair of coils having equal numbers of turns and equal diameters arranged with a common axis and connected in series such that the electrical current flows in opposite directions around both coils such that a magnetic field is produced. As would be understood by one of ordinary skill in the art, the "coil" of wire is not necessarily circular in shape. For example, a solenoidal-like coil may be constructed such that turns of coil at some points along the coil are closer together than at

other points in the coil. In addition, the coils may be in any shape, such as rectangles, squares, and ovals, so long as a magnetic field is produced by current flowing through the wires. Furthermore, the electric current carried by the wire may be either a direct current (DC) or a time-varying current, called an alternating current (AC). An alternating current may take any wave form, for example, sinusoidal, rectilinear, triangular and trapezoidal. Various waveforms may also be interchangeable.

[0032] The system 25 can be used to subject patients to the magnetic flux density. If a steady, static current, or a time-varying current, flows through a wire, such as the first and second coils 35 and 37, experiments have shown the electromagnetic field has biological parasympethetic and sympathetic effects. The system 25 can, therefore, be used to implement a method of treatment or prophylaxis of a disease state or a condition ameliorated or prevented by electromagnetic radiation. The method includes subjecting an organism to electromagnetic radiation having a magnetic flux density from about 5 X 10^{-6} gauss and about 1 X 10^{-12} gauss and a frequency between about zero and about 140 Hertz. The method, more particularly, is applied at very low frequencies in the range of about zero to about twenty eight Hertz (28 Hz).

[0033] The method can be used to ameliorate or prevent many common ailments. The diseased state or condition may include elevated heart rate, irregular heart rate, elevated blood pressure, cardiovascular failure, cancer, cataracts, immunological conditions (such as HIV/AIDS), blood clots, atrial fibrillation, ventricular fibrillation, and atrioventicular blockage. The diseased state or condition may also include diseased heart valves, enlarged heart, circulatory blockage, coronary insufficiencies, and ischemia.

[0034] Experiments have shown that electromagnetic radiation in the range of about one to about one hundred picoTesla (100 pT) (or between about 10^{-8} gauss to about 10^{-6} gauss) produces either parasympathetic or sympathetic effects. These parasympathetic and sympathetic effects occur when electromagnetic fields are impinged upon biosystems. Specifically, parasympathetic effects are observed when the electromagnetic radiation is administered in a range between about 10^{-12} gauss to about 3.4 X 10^{-8} gauss. More preferably, the electromagnetic radiation is administered in a range between about 2 X 10 10^{-8} gauss to about 3.8 X 10^{-8} gauss. Most preferably, the electromagnetic radiation is

administered in a range between about 2.8 X 10^{-8} gauss to about 3.4 X 10^{-8} gauss. Sympathetic effects are observed when the electromagnetic radiation is administered in a range between about 7.5 X 10^{-8} to about 1 X 10^{-6} gauss.

[0035] By comparison, much larger electromagnetic fields are present in the environment from a variety of sources. The geomagnetic field is about .5 gauss, which is millions of times stronger than the electromagnetic fields used in the system and method described herein. Electromagnetic fields are commonly used in a medical imaging technique called magnetic resonance imaging (MRI) to image internal structures. Typical MRI fields are about 10,000 gauss. Electromagnetic fields produced by power lines and household appliances are more than 100,000 times stronger than the fields used in the system and method described herein.

[0036] It is believed that these sympathetic and parasympathetic effects from weak or low electromagnetic fields (less than about 10^{-6} gauss, preferably about 10^{-8} gauss to about 10^{-6} gauss are based upon cellular resonances with particular masses associated with particular cellular dimensions and the cyclotron resonance associated with lower frequencies of electromagnetic fields. Thus, specific electromagnetic flux densities administered at specific frequencies stimulate ganglia on the heart that regulate, as part of the autonomic nervous system, the heart rate and electrical conduction in the heart. It is believed that the relation of subatomic particles to the distances a cell border covers in space-time regulate the structural and functional interactions of living matter. Thus, the relationship between subatomic particles and the distances the cell border covers determine the appropriate electromagnetic flux density and frequency for regulation of structural and functional interactions in a living system. *See* U.S. Patent 5,269,746 to Dr. Jerry I. Jacobson, issued December 14, 1993. The Jacobson equation is:

$$\mathrm{mc}^2 = \mathrm{B}lvq\,,$$

where

m = mass of a particle in a "box" or a "string;"

B = the magnetic flux density;

q = a unit charge of one Coulomb;

v = velocity of the carrier or "string" in which the particle exists, for example, the orbital or rotational velocity of the earth; and

l = length of the carrier or "string."

[0037] Specifically, the particle in the carrier (also referred to herein as a "box" or "string") may be a particle such as an electron, photon, or proton in a cell (carrier) or a molecule (particle) in a biological system (carrier). More specifically, the molecule may be any molecule critical to a biological system. Thus, if the carrier is an organism such as a dog or a human, the length of the carrier is the height of the organism. Harmonic resonances may be added by using the cell (or organelle) of the organism as the carrier, and a subatomic particle as the target particle.

[0038] Table 1 shows the magnetic flux density calculated for electrons and protons inside a cell. Thus, the length of the box is the diameter of the cell. The magnetic flux densities calculated in Table 1 (.028 - .034 μG) are typical for subatomic particles in a cell.

Table I

Mass	**Inertial Velocity (v)**	**Length of box (l)**	**Magnetic Profile (B) flux density**
(E) electron	earth rotational (ER) (4.6×10^4 cm/s)	5.3 microns	.034μG
e^-	ER	6.37 microns	.028μG
p^+	star cluster (3.2×10^7 cm/s)	1.36×10^{-3}cm	.034μG

[0039] Table 2 shows the calculation of the magnetic flux using the Jacobson equation for various molecules critical to biological systems. The resulting magnetic flux densities in living systems using critical molecules are similar to the magnetic flux densities for subatomic particles in a cell calculated in Table 1. Namely, these values are between about .028 μG and about .037 μG.

Table II

Mass	**Inertial Velocity (v)**	**Length of box (l)**	**Magnetic Profile (B)**
3,325.8 Daltons VIP-D-Phe-2	solar system 1.92×10^6cm/s	(dog) 70 cm	.037μG

vasointestinal peptide	(SS) SS	(dog) 76 cm	.037μG
VIP lys-1-pro-2,5 vasointestinal peptide	•earth orbital (EO) 3×10^6cm/s •EO	• dog 54 cm • dog 56 cm	.032μG .031μG
epinephrine 184 daltons	earth rotational (ER) 4.6×10^4cm/s	human 1.7×10^2cm	.0347μG
serotonin (176 Da)	ER	human	.032μG
Acetylcholine	ER	human	.0334μG
Tubulin Subunits (? and β)	SC	human	03μG
adenosine	EO	rat (22 cm)	.0346μG

[0040] The particles in this study are important, critical molecules and other particles selected based on their relationship to particular conditions. More specifically, the particles play a role in nerve repair, growth, and regeneration. Some examples of these important biological particles include nerve growth factor (NGF), homeoboxes, neurotransmitters, cytokines, motor proteins, and structural proteins. Some other examples include kinesine, microtubule associated protein (MAP), spectrin, brain specific fodrin, neurofilaments, tubulin, and platelet-derived growth factor (PDGF).

[0041] A critical molecule is selected, and the appropriate magnetic flux density is calculated. The frequency may also be calculated using the ion cyclotron resonance equation

$$f = \frac{qB}{2\pi m}$$

to determine the frequency of the externally-applied magnetic flux. Because the intensity B of the magnetic flux intensity was previously calculated using the Jacobson equation, the ion cyclotron resonance equation can be used to determine the frequency of the externally-applied magnetic flux. *See* U.S. Patent 5,269,746 to Dr. Jerry I. Jacobson, issued December 14, 1993.

[0042] It has been found that the heart rate, for example, can be slowed using a magnetic field in the range of about two (2) to about 3.4 picoTesla. The parasympathetic effects seem to be a consequence of stimulating ganglia on the heart which autonomically regulate electrical

conduction in the heart. Higher ranges of magnetic fields, from about zero to about one hundred picoTesla (100 pT), have, conversely, sympathetic effects. It is believed that parasympathetic and sympathetic effects are observed because inter-atomic relations as expressed in the Jacobson and the ion cyclotron resonance equations, regulate structural and functional interactions in all matter.

[0043] The following table may be used to determine the appropriate magnetic field and frequency to treat any condition dependent upon critical molecules of specific molecular weights. The appropriate magnetic field and frequency is determined using the Jacobson equation and the ion cyclotron resonance equation, respectively, by selecting a target molecule or particle relevant to the condition and selecting the magnetic field corresponding to the target molecule's mass. The magnetic field (B) is calculated either in accordance with the earth's orbital velocity, the earth's rotational velocity, or the start cluster velocity which the earth is in which circles the center of the Milky Way Galaxy (v). The velocity of the system corresponds to a harmonic resonance for the particular system. The (L) length used is 5'8" average human length. As would be understood by one of ordinary skill in the art, examples of critically important molecules relevant to cardiac patients include nerve growth factor (NGF), homeoboxes, neurotransmitters, cytokines, motor proteins, structural proteins, kinesine, microtubule associated protein (MAP), spectrin, brain specific fodrin, neurofilaments, tubulin, platelet derived growth factor (PDGF), and other biological molecules related to cardiac function. The mass of these critical or target particles is well known.

TABLE 3

Table For Humans

(Length = 1.7×10^2cm)

Inertial	3.22×10^7 cm/s	star cluster (SC)
Velocities:	2.98×10^6 cm/s	earth orbital (EO)
	4.642×10^4 cm/s	rotational earth (ER)

Note: 1 dalton is an atomic mass unit (a.m.u.) symbol: μ, which is conventionally assigned a value equal to one twelfth of an atom of the mass of the most abundant isotope of carbon, carbon 12. Therefore, carbon twelve is assigned an atomic mass unit, or dalton, of 12.

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.001	0.028000001	339.321	3619.424
0.002	0.055000001	678.642	7238.848
0.003	0.084000002	1017.963	10858.272
0.004	0.112000002	1357.284	14477.696
0.005	0.140000030	1696.605	18067.120
0.006	0.168000003	2036.926	21716.544
0.007	0.196000004	2375.247	25335.968
0.008	0.224000004	2714.568	28955.392
0.009	0.252000005	3053.889	32574.816
0.010	0.280000006	3393.210	36194.240
0.011	0.308000006	3732.531	39813.664
0.012	0.336000007	4071.852	43433.088
0.013	0.640000070	4411.173	47052.512
0.014	0.392000008	4750.494	50871.936
0.015	0.420000008	5089.815	54291.360
0.016	0.448000009	5429.136	57910.784
0.017	0.478000010	5768.457	61530.208
0.018	0.504000010	6107.778	65149.632
0.019	0.532000011	6447.099	68769.058
0.020	0.560000011	6786.420	72388.480
0.021	0.588000012	7125.741	76007.904
0.022	0.618000012	7465.062	79627.328
0.023	0.644000013	7804.383	83246.752
0.024	0.372000013	8143.704	86866.176
0.025	0.700000014	8483.025	90485.600
0.026	0.728000015	8822.346	94105.240
0.027	0.756000015	9161.667	97724.448
0.028	0.854000016	9500.988	101343.872
0.029	0.812000016	9840.309	107963.296
0.030	0.840000017	10179.630	108582.720
0.031	0.868000017	10518.951	112202.144
0.032	0.896000018	10856.272	115821.568
0.033	0.924000018	11197.593	119440.992
0.034	0.952000019	11536.914	123060.416
0.035	0.980000020	11876.235	126679.840
0.036	1.008000020	12215.656	130299.264
0.037	1.036000021	12554.877	133918.888
0.038	1.064000021	12894.198	137538.112
0.039	1.092000022	13233.519	141157.538
0.040	1.120000022	13572.840	144776.960
0.041	1.148000023	13912.161	148396.384
0.042	1.176000024	14251.482	152015.808
0.043	1.204000024	15690.803	155835.232
0.044	1.232000025	14930.124	159254.658
0.045	1.260000025	15269.445	162874.080
0.046	1.288000026	15608.766	166493.504
0.047	1.316000026	15978.087	170112.928
0.048	1.344000027	16287.408	173732.352
0.049	1.372000027	16626.729	177351.776

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.050	1.400000028	16966.050	180971.200
0.051	1.428000029	17305.371	184590.624
0.052	1.456000029	17644.692	188210.048
0.053	1.484000030	17984.013	191829.472
0.054	1.512000030	18323.334	196448.896
0.055	1.640000031	18662.655	199068.320
0.056	1.568000031	19001.976	202687.744
0.057	1.596000032	19341.297	206307.168
0.058	1.624000032	19680.618	209926.592
0.059	1.652000033	20019.939	213546.016
0.060	1.680000034	20359.260	217165.440
0.061	1.708000034	20696.581	220784.864
0.062	1.736000035	21037.902	224404.288
0.063	1.764000035	21377.223	228023.712
0.064	1.792000036	21716.544	231643.163
0.065	1.820000036	22066.866	235262.560
0.066	1.848000037	22395.186	238881.984
0.067	1.876000038	22734.507	242501.408
0.068	1.904000038	23073.828	246120.832
0.069	1.932000039	23413.149	249740.256
0.070	1.960000039	23752.470	253359.680
0.071	1.988000040	24091.791	256979.104
0.072	2.016000040	24431.112	260598.528
0.073	2.044000041	24770.433	264217.952
0.074	2.072000041	25109.754	267837.376
0.075	2.100000042	25449.075	271456.800
0.076	2.128000043	25788.396	275076.224
0.077	2.156000043	26127.717	278695.648
0.078	2.184000044	26467.038	282315.072
0.079	2.212000044	26806.359	285934.496
0.080	2.240000045	27145.680	289553.920
0.081	2.268000045	27485.001	293173.344
0.082	2.296000046	27824.322	296792.768
0.083	2.324000046	28163.643	300412.192
0.084	2.352000047	28502.964	304031.616
0.085	2.380000028	28842.285	307651.040
0.086	2.408000048	29181.606	311270.464
0.087	2.436000049	29520.927	314889.888
0.088	2.464000049	29860.248	318509.312
0.089	2.492000050	30199.569	322128.736
0.090	2.520000050	30538.890	325748.160
0.091	2.548000051	30878.211	329367.584
0.092	2.576000052	31217.532	332987.008
0.093	2.604000052	31556.853	336606.432
0.094	2.632000053	31896.174	340225.856
0.095	2.660000053	32235.495	343845.280
0.096	2.688000054	32874.816	347464.704
0.097	2.716000054	32914.137	351084.128
0.098	2.744000055	33253.458	354703.552

$\overline{B}$ (microgauss) FIELD	(Hertz) FREQUENCY	target masses in (daltons) EO	target masses in (daltons) SC
0.099	2.722000055	33592.779	358322.976
0.100	2.800000056	33932.100	361942.400
0.101	2.828000057	34271.421	365561.824
0.102	2.856000057	34610.742	369181.248
0.103	2.884000058	34950.063	372800.672
0.104	2.912000058	35289.384	376420.096
0.105	2.940000059	35628.705	380039.520
0.106	2.968000059	35968.026	383658.944
0.107	2.996000060	36307.347	387278.368
0.108	3.024000060	38646.668	390897.792
0.109	3.052000061	36985.989	394517.216
0.110	3.080000062	37325.31	398136.640
0.111	3.108000062	37664.631	401756.064
0.112	3.136000063	38003.952	405375.488
0.113	3.164000083	38343.273	408994.912
0.114	3.192000064	38682.594	412614.336
0.115	3.220000064	39021.915	416233.760
0.116	3.248000065	39361.236	419853.184
0.117	3.276000066	39700.557	423472.608
0.118	3.304000066	40039.878	427092.032
0.119	3.332000067	40379.199	430711.456
0.120	3.360000067	40718.520	434330.880
0.121	3.388000068	41057.841	437950.304
0.122	3.416000068	41397.162	441589.728
0.123	3.444000069	41736.483	445189.152
0.124	3.472000069	42075.804	448808.576
0.125	3.500000070	42415.125	452428.000
0.126	3.528000071	42754.446	456047.424
0.127	3.556000071	43093.767	459666.848
0.128	3.584000072	43433.088	463286.272
0.129	3.612000072	43772.409	466905.696
0.130	3.640000073	44111.730	470525.100
0.131	3.668000073	44451.051	474144.544
0.132	3.696000074	44790.372	477763.968
0.133	3.724000074	45129.693	481383.392
0.134	3.752000076	45469.014	485002.816
0.135	3.780000076	45808.335	488622.240
0.136	3.808000076	46147.658	492241.664
0.137	3.936000077	46486.977	495861.088
0.138	3.864000077	46826.298	499480.512
0.139	3.892000078	47165.619	50309.936
0.140	3.920000078	47504.940	506719.360
0.141	3.948000079	47844.261	510338.784
0.142	3.976000080	48183.582	513958.208
0.143	4.004000080	48522.903	517577.632
0.144	4.032000081	48862.224	521197.056
0.145	4.060000810	49201.545	524816.480
0.146	4.088000082	49540.866	528435.904
0.147	4.116000082	49880.187	532055.328

B (microgauss) FIELD	(Hertz) FREQUENCY	target masses in (daltons) EO	target masses in (daltons) SC
0.148	4.144000083	50219.508	535674.752
0.149	4.172000083	50558.829	539294.176
0.150	4.200000084	50898.150	542913.600
0.151	4.228000085	51237.471	546?33.024
0.152	4.258000085	51576.792	550152.448
0.153	4.284000086	51916.113	553771.872
0.154	4.312000086	52255.434	557391.296
0.155	4.340000087	52594.755	561010.720
0.156	4.368000087	52934.076	564630.144
0.157	4.396000088	53273.397	568249.568
0.158	4.424000088	53812.718	571868.992
0.159	4.452000089	53952.039	575488.416
0.160	4.480000090	54291.360	579107.840
0.161	4.508000090	54630.681	582727.264
0.162	4.536000091	54970.002	586346.688
0.163	4.564000091	55309.323	589966.112
0.164	4.592000092	55648.644	593585.536
0.165	4.620000092	55987.965	597204.960
0.166	4.648000093	56327.286	600824.384
0.167	4.676000094	56686.607	604443.808
0.168	4.704000094	57005.928	608063.232
0.169	4.732000095	57345.249	611682.858
0.170	4.760000095	57684.570	615302.080
0.171	4.788000096	58023.891	618921.504
0.172	4.816000096	58363.212	622540.928
0.173	4.844000097	58702.533	628160.352
0.174	4.872000097	59041.854	629779.776
0.175	4.900000098	59381.175	633399.200
0.176	4.928000099	59720.496	637018.624
0.177	4.856000099	60059.817	640838.048
0.178	4.984000100	60399.138	644257.472
0.179	5.012000100	60738.459	647876.896
0.180	5.040000101	61077.780	651496.320
0.181	5.068000101	61417.101	655115.744
0.182	5.096000102	61756.422	658735.168
0.183	5.124000102	62095.743	662354.592
0.184	5.152000103	62435.064	665974.016
0.185	5.180000104	52774.385	669593.440
0.186	5.208000104	63113.706	763212.864
0.187	5.236000105	63453.027	676832.288
0.188	5.264000105	63792.348	680451.712
0.189	5.292000106	64131.669	684071.136
0.190	5.320000106	64470.99	687690.560
0.191	5.348000107	64810.311	691309.984
0.192	5.376000108	65149.532	694929.408
0.193	5.404000108	65488.953	698548.832
0.194	5.432000109	65828.274	702168.256
0.195	5.460000109	66167.595	705787.680
0.196	5.488000110	66506.916	709407.104

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.197	5.516000110	66846.237	713026.528
0.198	5.544000111	67185.558	716645.952
0.199	5.572000111	67524.879	720265.376
0.200	5.600000112	67864.200	723884.800
0.201	5.628000113	68203.521	727504.224
0.202	5.656000113	68542.842	731123.648
0.203	5.684000114	68882.163	744743.072
0.204	5.712000114	69221.484	7.8362.496
0.205	5.740000115	69560.805	741981.920
0.206	5.768000115	69900.126	745801.344
0.207	5.796000116	70239.447	749220.768
0.208	5.824000116	70578.768	752840.192
0.209	5.852000117	70918.089	756459.616
0.210	5.880000118	71257.410	760079.040
0.211	5.908000118	71596.731	763698.464
0.212	5.936000119	71936.052	767317.888
0.213	5.964000119	72275.373	770937.312
0.214	5.992000120	72614.694	774556.738
0.215	6.020000120	72954.015	778178.160
0.216	6.048000121	73293.336	781795.584
0.217	6.076000122	73832.657	785415.008
0.218	6.104000122	73971.978	789034.432
0.219	6.132000123	74311.299	492653.856
0.220	6.160000123	74650.620	796372.280
0.221	6.188000124	74989.941	799892.704
0.222	6.216000124	75329.262	803512.128
0.223	6.244000125	75888.583	807161.552
0.224	6.272000125	76007.904	810750.976
0.225	6.300000126	76347.225	814370.400
0.226	6.328000127	76686.646	817989.824
0.227	6.356000127	77025.867	821609.248
0.228	6.384000128	77365.188	825228.672
0.229	6.412000128	77704.509	828848.096
0.230	6.440000129	78043.830	832467.520
0.231	6.468000129	78383.151	836086.944
0.232	6.496000130	78722.472	839706.368
0.233	6.524000130	79061.973	843325.792
0.234	6.552000131	79401.114	846945.206
0.235	6.580000132	79740.435	850564.640
0.236	6.608000132	80079.756	864184.064
0.237	6.636000133	80419.077	857803.488
0.238	6.684000133	80758.398	831422.912
0.239	6.692000134	81097.719	865042.336
0.240	6.720000134	81437.040	868661.760
0.241	6.748000135	81776.361	872281.184
0.242	6.776000136	82115.882	875900.608
0.243	6.804000136	82455.003	879520.032
0.244	6.832000137	82791.324	883139.456
0.245	6.860000137	93133.645	886759.880

— B (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.246	6.888000138	83472.966	890378.304
0.247	6.916000138	83812.287	893997.728
0.248	6.944000139	84151.608	897617.152
0.249	6.972000139	84490.929	901236.576
0.250	7.000000140	84830.250	904856
0.251	7.028000141	95169.571	908475.424
0.252	7.055000141	85508.892	912094.848
0.253	7.084000142	85848.213	915714.272
0.254	7.112000142	86187.534	919333.696
0.255	7.140000143	86526.855	922953.120
0.256	7.168000143	86866.176	926572.544
0.257	7.196000144	87205.497	930191.968
0.258	7.224000144	87544.818	933811.392
0.259	7.252000145	87884.139	937430.816
0.260	7.280000146	88223.460	941050.240
0.261	7.308000146	88562.791	944668.664
0.262	7.336000147	88902.102	948289.088
0.263	7.364000147	89241.423	951908.512
0.264	7.392000148	89580.744	955527.936
0.265	7.420000148	89920.065	959147.360
0.266	7.448000149	90259.386	952766.784
0.267	7.476000150	90598.707	966386.208
0.268	7.504000150	90938.028	970005.632
0.269	7.532000151	91277.349	97362.056
0.270	7.560000151	91616.670	977244.480
0.271	7.588000152	91955.991	980863.904
0.272	7.616000152	92295.312	984483.328
0.273	7.644000153	92634.633	988102.752
0.274	7.672000153	92973.954	991722.176
0.275	7.700000154	93313.275	995341.600
0.276	7.728000155	93652.596	998961.024
0.277	7.756000155	93991.917	1002580.448
0.278	7.784000156	94331.238	1006199.872
0.279	7.812000156	94670.559	1009819.296
0.280	7.840000157	95009.880	1013438.720
0.281	7.868000157	95349.201	1017058.144
0.282	7.896000158	95688.522	1020677.568
0.283	7.924000158	96027.643	1024296.992
0.284	7.952000159	96367.164	1027916.416
0.285	7.980000160	96706.485	1031535.840
0.286	8.008000160	97045.806	1035155.264
0.287	8.036000161	97385.127	1038774.688
0.288	8.064000161	97724.448	1042394.112
0.289	8.092000162	98063.769	1046013.536
0.290	8.120000162	98403.090	1049632.960
0.291	8.148000163	98742.411	1053252.384
0.292	8.176000164	99081.732	1056871.808
0.293	8.204000164	99421.053	1060491.232
0.294	8.232000165	99760.374	1064110.656

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.295	8.260000165	100099.695	1067730.080
0.296	8.288000168	100439.016	1071349.504
0.297	8.316000166	100778.337	1072968.928
0.298	8.344000167	101117.658	1078588.352
0.299	8.372000167	101456.979	1082207.776
0.300	8.400000168	101796.300	1085827.200
0.301	8.428000169	102135.621	1089446.624
0.302	8.456000169	102474.942	1093066.048
0.303	8.484000170	102814.263	1096685.472
0.304	8.512000170	103153.584	1100304.896
0.305	8.640000171	103492.905	1103924.320
0.306	8.568000171	103832.226	1107543.744
0.307	8.596000172	104171.547	1111163.168
0.308	8.624000192	104510.868	1114782.592
0.309	8.652000173	104850.189	1118402.016
0.310	8.680000174	105189.510	1122021.440
0.311	8.708000174	105528.831	1125640.864
0.312	8.836000175	105868.152	1129260.288
0.313	8.764000175	106207.473	1132879.712
0.314	8.792000176	106546.794	1136499.136
0.315	8.820000176	106886.115	1140118.560
0.316	8.848000177	107225.436	1143737.984
0.317	8.876000178	107564.757	1147357.408
0.318	8.904000178	107904.078	1150976.832
0.319	8.932000179	108243.399	1154596.256
0.320	8.960000179	108582.720	1158215.680
0.321	8.988000180	108922.041	1161835.104
0.322	9.016000180	109261.362	1165454.528
0.323	9.044000181	109600.683	1169073.952
0.324	9.072000181	109940.004	1172693.376
0.325	9.100000182	110279.325	1176312.800
0.326	9.128000183	110618.646	1179932.224
0.327	9.156000183	110957.967	1183551.648
0.328	9.184000184	111297.288	1187171.072
0.329	9.212000184	111636.609	1190790.496
0.330	9.240000185	111975.930	1194409.920
0.331	9.268000185	112315.251	1198029.344
0.332	9.296000186	112654.572	1201648.768
0.333	9.324000186	112993.893	1205268.192
0.334	9.352000187	113333.214	1208887.616
0.335	9.380000188	113672.535	1212507.040
0.336	9.408000188	114011.856	1216126.464
0.337	9.436000189	114351.177	1219745.888
0.338	9.464000189	114890.498	1223365.312
0.339	9.492000190	115029.819	1226984.736
0.340	9.520000190	115369.140	1230604.160
0.341	9.548000191	115705.461	1234223.584
0.342	8.576000192	116047.782	1237843.008
0.343	9.604000192	116387.103	1241462.432

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.344	9.632000193	116726.424	1245081.856
0.345	9.680000193	117065.745	1248701.280
0.346	9.688000194	117405.086	1252320.704
0.347	9.716000194	117744.387	1255940.128
0.348	9.744000195	118083.708	1259559.552
0.349	9.772000195	118423.029	1263178.976
0.350	9.800000196	118762.350	1266798.400
0.351	9.828000197	119101.671	1270417.824
0.352	9.858000197	119440.992	1274037.248
0.353	9.884000198	119780.313	1277656.672
0.354	9.912000198	120119.634	1281276.096
0.355	9.940000199	120458.955	1284895.520
0.356	9.968000199	120798.276	1288514.944
0.357	9.996000200	121137.597	1292134.368
0.358	10.024000200	121476.918	1295759.792
0.359	10.052000200	121816.239	1299373.216
0.360	10.080000200	122155.560	1302992.640
0.361	10.108000200	122494.881	1306612.064
0.362	10.138000200	122834.202	1310231.488
0.363	10.164000200	123173.523	1313850.912
0.364	10.192000200	123512.844	1317470.336
0.365	10.220000200	123852.165	1321089.760
0.366	10.248000200	124191.486	1324709.184
0.367	10.276000210	124530.807	1328328.608
0.368	10.304000210	124870.128	1331948.032
0.369	10.332000210	125209.449	1335567.456
0.370	10.360000210	125548.770	1339186.880
0.371	10.388000210	125888.091	1342806.304
0.372	10.416000210	126227.412	1346425.728
0.373	10.444000210	126566.733	1650045.152
0.374	10.472000210	126906.054	1353664.576
0.375	10.500000210	127245.375	1357284.000
0.376	10.528000210	127584.696	1360903.424
0.377	10.558000210	127924.017	1364522.848
0.378	10.584000210	128263.338	1368142.272
0.379	10.612000210	128602.659	1371761.696
0.380	10.640000210	128941.980	1375381.120
0.381	10.66800021	129281.301	1379000.544
0.382	10.969000210	129620.622	1382619.968
0.383	10.724000210	129959.943	1386239.392
0.384	10.752000220	130299.264	1389858.815
0.385	10.780000220	130638.585	1393478.240
0.386	10.808000220	130977.906	1397097.664
0.387	10.838000220	131317.227	1400717.088
0.388	10.864000220	131656.548	1404336.512
0.389	10.892000220	131995.869	1407955.936
0.390	10.920000220	132335.190	1411575.360
0.391	10.948000220	132674.511	1415194.784
0.392	10.976000220	133013.832	1418814.208

$\overline{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.393	11.004000220	133353.153	1422433.632
0.394	11.032000220	133682.474	1426053.058
0.395	11.060000220	134031.795	1429672.480
0.396	11.088000220	134371.116	1433291.904
0.397	11.116000220	134710.437	1436911.328
0.398	11.144000220	135049.758	1440530.762
0.399	11.172000220	135389.079	1444150.176
0.400	11.200000220	135728.400	1447769.600
0.401	11.228000220	136067.721	1451389.024
0.402	11.256000230	136407.042	1455008.448
0.403	11.274000230	136746.363	1458627.872
0.404	11.312000230	137085.684	1462247.296
0.405	11.340002300	137425.005	1465886.720
0.406	11.368000230	137764.326	1469486.144
0.407	11.396000230	138103.647	1473105.568
0.408	11.424000230	138442.968	1476724.992
0.409	11.452000230	138782.289	1480344.416
0.410	11.480000230	139121.610	1483963.840
0.411	11.508000230	139460.931	1487583.264
0.412	11.536000230	139800.252	1491202.688
0.413	11.564000230	140139.573	1494822.112
0.414	11.692000230	140478.894	1498441.536
0.415	11.620000230	170818.215	1502060.960
0.416	11.648000230	141157.536	1505680.384
0.417	11.676000230	141496.857	1509299.808
0.418	11.704000230	141836.178	1512919.232
0.419	11.732000230	142175.499	1518538.656
0.420	11.760000240	142514.820	1520158.080
0.421	11.788000240	142854.141	1523777.504
0.422	11.816000240	143193.462	1527396.928
0.423	11.844000240	143532.783	1531016.352
0.424	11.872000240	143872.104	1534635.776
0.425	11.900000240	144211.425	1538255.200
0.426	11.928000240	144550.746	1541874.624
0.427	11.956000240	144890.067	1545494.048
0.428	11.984000240	145229.388	1549113.482
0.429	12.012000240	145568.709	1552732.896
0.430	12.040000240	145906.030	1556352.320
0.431	12.068000240	146247.351	1559971.744
0.432	12.096000240	146586.672	1563691.168
0.433	12.124000240	146925.993	1567210.592
0.434	12.152000240	147265.314	1570830.018
0.435	12.180000240	147604.635	1574449.440
0.436	12.208000240	147943.956	1578068.864
0.437	12.236000240	148283.277	1581688.288
0.438	12.264000250	148622.598	1585307.712
0.439	12.282000250	148961.919	1588927.136
0.440	12.320000250	149301.240	1592546.560
0.441	12.348000250	149640.561	1596165.984

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.442	12.386000250	149979.882	1599785.408
0.443	12.404000250	150319.203	1603404.832
0.444	12.432000250	150658.524	1607024.256
0.445	12.460000250	150997.845	1610643.680
0.446	12.488000250	151337.166	1614263.104
0.447	12.516000250	151676.487	1617882.528
0.448	12.544000250	152015.808	1621501.952
0.449	12.572000250	152355.129	1625121.376
0.450	12.600000250	152694.450	1628740.800
0.451	12.628000250	1533033.771	1632360.224
0.452	12.656000250	153373.092	1635979.648
0.453	12.684000250	153712.413	1639599.072
0.454	12.712000250	154051.734	1643218.496
0.455	12.740000250	154391.055	1646837.920
0.456	12.768000260	154730.376	1650457.344
0.457	12.796000260	155069.697	1654076.768
0.458	12.824000260	155409.018	1657696.792
0.459	12.852000260	155748.339	1661315.616
0.460	12.880000260	156087.660	1664935.040
0.461	12.908000260	156426.981	1668554.464
0.462	12.936000260	156766.302	1672173.888
0.463	12.964000260	157105.523	1675793.312
0.464	12.992000260	157444.944	1679412.736
0.465	13.020000260	157784.265	1383032.160
0.466	13.048000260	158123.586	1686651.584
0.467	13.076000260	128462.907	1690271.008
0.468	13.104000260	158802.228	1693890.432
0.469	13.132000260	159141.549	1697509.856
0.470	13.160000260	159480.870	1701129.280
0.471	13.188000260	159820.191	1704748.704
0.472	13.216000260	160159.512	1708368.128
0.473	13.244000260	160498.833	1711987.552
0.474	13.272000270	160838.154	1715606.976
0.475	13.300000270	161177.475	1719226.400
0.476	13.328000270	161516.795	1722845.824
0.477	13.356000270	161856.117	1726465.248
0.478	13.384000270	162195.438	1730084.672
0.479	13.412000270	162534.759	1733704.096
0.480	13.440000270	162874.080	1737323.520
0.481	13.468000270	163213.401	1740942.944
0.482	13.496000270	163552.722	1744562.368
0.483	13.524000270	163892.043	1748181.792
0.484	13.552000270	164231.364	1751801.216
0.485	13.580000270	164570.685	1755420.640
0.486	13.608000270	164910.006	1759040.064
0.487	13.636000270	165249.327	1762659.488
0.488	13.664000270	165588.648	1766276.810
0.489	13.692000270	165927.969	1769898.336
0.490	13.720000270	166287.29	1773517.760

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.491	13.748000270	166606.611	1777137.184
0.492	13.778000280	166945.932	1780756.608
0.493	13.804000280	167285.253	1784376.032
0.494	13.832000280	167624.574	1787995.456
0.495	13.860000280	167963.895	1791614.880
0.496	13.888000280	168303.216	1795234.304
0.497	13.916000280	168642.537	1798853.728
0.498	13.944000280	168981.858	1802473.152
0.499	13.972000280	169321.179	1806092.567
0.500	14.000000280	169660.500	1809712.000
0.501	14.028000280	169999.821	1813331.424
0.502	14.056000280	170339.142	1816950.848
0.503	14.084000280	170678.463	1820570.272
0.504	14.112000280	171017.784	1824189.696
0.505	14.140000280	171367.105	1827809.120
0.506	14.168000280	171696.426	1831428.544
0.507	14.196000280	172035.747	1835047.968
0.508	14.224000280	172375.068	1838667.392
0.509	14.252000290	172714.389	1842286.816
0.510	14.280000290	173053.710	1845906.240
0.511	14.308000290	173393.031	1849525.664
0.512	14.336000290	173732.352	1853145.088
0.513	14.364000290	174071.673	1856764.512
0.514	14.392000290	174410.994	1860383.936
0.515	14.420000290	174750.315	1864003.360
0.516	14.448000290	175089.636	1867622.784
0.517	14.476000290	175428.957	1871242.208
0.518	14.504000290	175768.278	1874861.632
0.519	14.532000290	176107.599	1878481.058
0.520	14.560000290	176446.920	1882100.480
0.521	14.588000290	176786.241	1885719.904
0.522	14.616000290	177125.562	1889339.328
0.523	14.644000290	177464.883	1892958.752
0.524	14.672000290	177804.204	1896578.176
0.525	14.700000290	178143.525	1900197.600
0.526	14.728000290	178482.846	1903817.024
0.527	14.756000300	178822.167	1907436.448
0.528	14.784000300	179161.488	1911055.872
0.529	14.812000300	179500.809	1914675.296
0.530	14.840000300	179840.130	1918294.720
0.531	14.868000300	180179.451	1921914.144
0.532	14.896000300	180518.772	1925533.568
0.533	14.924000300	180858.093	1929152.992
0.534	14.952000300	181197.414	1932772.416
0.535	14.980000300	181536.735	1936391.840
0.536	15.005000300	181876.056	1940011.264
0.537	15.036000300	182215.377	1943630.688
0.538	15.064000300	182554.698	1947250.112
0.539	15.092000300	182894.019	1950869.536

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.540	15.120000300	183233.340	1954488.960
0.541	15.148000300	183572.661	1958108.384
0.542	15.176000300	183911.982	1961727.808
0.543	15.204000300	184251.303	1965347.232
0.544	15.232000300	184590.624	1968966.656
0.545	15.260000310	184929.945	1972586.080
0.546	15.288000310	185269.266	1976205.504
0.547	15.316000310	185608.587	1979824.928
0.548	15.344000310	185947.908	1983444.352
0.549	15.372000310	186287.229	1987063.776
0.550	15.400000310	186626.550	1990683.200
0.551	15.428000310	186965.871	1994302.624
0.552	15.456000310	187305.192	1997922.048
0.553	15.484000310	187644.513	2001541.472
0.554	15.512000310	187983.834	2005160.896
0.555	15.540000310	188323.155	2008780.320
0.556	15.568000310	188662.476	2012399.744
0.557	15.596000310	189001.797	2016019.168
0.558	15.624000310	189341.118	2019638.592
0.559	15.652000310	189??0.439	2023258.016
0.560	15.680000310	190019.760	2026877.440
0.561	15.708000310	190359.081	2030496.864
0.562	15.736000310	190698.402	2034116.288
0.563	15.764000320	191037.723	2037735.712
0.564	15.792000320	191377.044	2041355.136
0.565	15.820000320	191716.385	2044974.560
0.566	15.848000320	192055.686	2048593.984
0.567	15.876000320	192395.007	2052213.408
0.568	15.904000320	192734.328	2055832.832
0.569	15.932000320	193073.649	2059452.256
0.570	15.960000320	193412.970	2063071.?8
0.571	15.988000320	193752.291	2066691.104
0.572	16.016000320	194091.612	2070310.528
0.573	16.044000320	194430.933	2073929.952
0.574	16.072000320	194770.254	2077549.376
0.575	16.100000320	195109.575	2081168.800
0.576	16.128000320	195448.896	2084788.224
0.577	16.156000320	195788.217	2088407.648
0.578	16.184000320	196127.538	2092027.072
0.579	16.212000320	196466.859	2095646.496
0.580	16.240000320	196806.180	2099265.920
0.581	16.268000330	197145.501	2102885.344
0.582	16.296000330	197484.822	2106504.768
0.583	16.324000330	197824.143	2110124.192
0.584	16.352000330	198163.434	2113743.616
0.585	16.380000330	198502.785	2117363.040
0.586	16.408000330	198842.106	2120982.464
0.587	16.436000330	199181.427	2124601.888
0.588	16.464000330	199620.748	2128221.312

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.589	16.492000330	199860.069	2131840.736
0.590	16.520000330	200199.390	2135460.160
0.591	16.548000330	200538.711	2139079.581
0.592	16.576000330	200878.032	2142699.008
0.593	16.604000330	201217.353	2146318.432
0.594	16.632000330	201556.674	2149937.856
0.595	16.660000330	201895.995	2153557.280
0.596	16.688000330	202235.316	2157176.704
0.597	16.716000330	202574.634	2160796.128
0.598	16.744000330	202913.958	2164415.552
0.599	16.772000340	203253.279	2168034.976
0.600	16.800000340	203592.600	2171654.400
0.601	16.828000340	203931.921	2175273.824
0.602	16.856000340	204271.242	2178893.248
0.603	16.884000340	204610.563	2182512.672
0.604	16.912000340	204949.884	2188132.096
0.605	16.940000340	205289.205	2189751.520
0.606	16.968000340	205628.526	2193370.944
0.607	16.996000340	205976.847	2196990.368
0.608	17.024000340	206307.168	2200609.792
0.609	17.052000340	206646.489	2204229.216
0.610	17.080000340	206985.810	2207848.640
0.611	17.108000340	207325.131	2211468.064
0.612	17.136000340	207664.452	2215087.488
0.613	17.164000340	208003.773	2218706.912
0.614	17.192000340	208343.094	2222326.336
0.615	17.220000340	208682.415	2225945.760
0.616	17.248000340	209021.736	2229565.184
0.617	17.276000350	209361.057	2233184.608
0.618	17.304000350	209700.378	2236804.032
0.619	17.332000350	210039.699	2240423.456
0.620	17.360000350	210379.020	2244042.880
0.621	17.388000350	210718.341	2247662.304
0.622	17.41600035	211057.662	2251281.728
0.623	17.444000350	211396.983	2254901.152
0.624	17.472000350	211736.304	2258520.576
0.625	17.500000350	212075.625	2262140.000
0.626	17.528000350	212414.946	2265759.424
0.627	17.550003500	212754.267	2269378.848
0.628	17.584000350	213093.588	2272998.272
0.629	17.612000350	213432.909	2276617.696
0.630	17.640000350	213772.230	2280237.120
0.631	17.66800035	214111.551	2283856.544
0.632	17.696000350	214450.872	2287475.968
0.633	17.724000350	214790.193	2291095.392
0.634	17.752000360	215139.514	2294714.816
0.635	17.780000360	215468.835	2298334.240
0.636	17.808000360	215808.156	2301953.664
0.637	17.836000360	216147.477	2305573.088

$\bar{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.638	17.864000360	216486.798	2309192.512
0.639	17.892000360	216826.119	231281.936
0.640	17.920000360	217165.440	2316431.360
0.641	17.940003600	215704.761	2320050.784
0.642	17.976000360	217844.082	2323670.208
0.643	18.004000360	218183.403	2327289.632
0.644	18.032000360	218522.724	2330909.056
0.645	18.060000360	218862.045	2334528.460
0.646	18.088000360	219201.366	2338147.904
0.647	18.116000360	219540.687	2341767.328
0.648	18.144000360	219880.008	2345386.752
0.649	18.172000360	220219.329	2349006.176
0.650	18.200000360	220558.650	2352825.600
0.651	18.228000360	220897.971	2356245.024
0.652	18.256000370	221237.292	2359867.448
0.653	18.284000370	221576.613	2363483.872
0.654	18.312000370	221915.934	2367103.296
0.655	18.340000370	222255.255	2370722.720
0.656	18.368000370	222594.576	2374342.144
0.657	18.396000370	222933.897	2377961.588
0.658	18.424000370	223273.218	2381580.992
0.659	18.452000370	223612.539	2385200.416
0.660	18.480000370	223951.860	2388819.840
0.661	18.508000370	224291.181	2392439.264
0.662	18.536000370	224630.502	2396058.888
0.663	18.564000370	224969.823	2399678.112
0.664	18.592000370	225309.144	2403297.536
0.665	18.620000370	225648.465	2406916.960
0.666	18.648000370	225987.786	2410538.384
0.667	18.676000370	226327.107	2414155.808
0.668	18.704000370	226666.428	2417775.232
0.669	18.732000370	227005.749	2421394.858
0.670	18.760000380	227345.070	2425014.080
0.671	18.788000380	227684.391	2428633.504
0.672	18.816000380	228023.712	2432252.928
0.673	18.844000380	228363.033	2435872.352
0.674	18.87200038	228702.354	2439491.776
0.675	18.900000380	229041.675	2443111.200
0.676	18.928000380	229380.996	2446730.624
0.677	18.958000380	229720.317	2460350.048
0.678	18.984000380	230059.638	2453969.472
0.679	19.012000380	230398.959	2457588.896
0.680	19.040000380	230738.280	2461208.320
0.681	19.068000380	321077.601	2464827.744
0.682	19.096000380	231416.922	2468447.168
0.683	19.124000380	231756.243	2472066.592
0.684	19.152000380	232095.564	2475686.016
0.685	19.180000380	232434.885	2479305.110
0.686	19.208000380	232774.206	2482924.864

— B (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.687	19.236000380	233113.527	2486544.288
0.688	19.264000390	233452.848	2490163.712
0.689	19.292000390	233792.169	2493783.136
0.690	19.320000390	234131.490	2497402.560
0.691	19.348000390	234470.811	2501021.984
0.692	19.376000390	234810.132	2504641.408
0.693	19.404000390	235149.453	2508260.832
0.694	19.432000390	235488.774	2511880.256
0.695	19.46000039	235828.095	2515499.680
0.696	19.488000390	236167.416	2519119.104
0.697	19.516000390	236506.737	2520738.528
0.698	19.544000390	236845.058	2526357.952
0.699	19.572000390	237185.379	2529977.376
0.700	19.600000390	237524.700	2533596.800
0.701	19.628000390	237864.021	2537216.224
0.702	19.656000390	238203.342	2540835.648
0.703	19.684000390	238542.663	2544455.072
0.704	19.712000390	238881.984	2548074.496
0.705	19.740000390	239221.305	2551693.920
0.706	19.768000400	239560.626	2555313.344
0.707	19.796000400	239899.947	2558932.768
0.708	19.824000400	240239.268	2562552.192
0.709	19.852000400	240578.589	2566171.616
0.710	19.880000400	240917.910	2569791.040
0.711	19.908000400	241257.231	2573410.464
0.712	19.936000400	241596.552	2577029.888
0.713	19.964000400	241935.873	2580649.312
0.714	19.992000400	242275.194	2584268.736
0.715	20.020000400	242614.515	2587888.160
0.716	20.048000400	242953.836	2591507.584
0.717	20.086000400	243293.157	2595127.008
0.718	20.104000400	243632.478	2598746.432
0.719	20.132000400	243971.799	2602365.856
0.720	20.160000400	244311.120	2605985.280
0.721	20.188000400	244650.441	2609604.704
0.722	20.216000400	244989.762	2613224.128
0.723	20.244000200	245329.083	2616843.552
0.724	20.272000410	245668.404	2820482.976
0.725	20.300000410	246007.725	2624082.400
0.726	20.328000410	246347.046	2627701.842
0.727	20.356000410	246686.367	2631321.248
0.728	20.384000410	247025.688	2634940.672
0.729	20.412000410	247365.009	2638580.096
0.730	20.440000410	247704.330	2642179.520
0.731	20.468000410	248043.651	2645798.844
0.732	20.496000410	248382.972	2649418.368
0.733	20.524000410	248722.293	2653037.792
0.734	20.552000410	249061.614	2856657.216
0.735	20.580000410	249400.935	2660276.640

— B (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.736	20.608000410	249740.256	2663896.064
0.737	20.636000410	250079.577	2667515.488
0.738	20.651000410	250418.898	2671134.912
0.739	20.692000410	250758.219	2674754.336
0.740	20.720000410	251097.540	2678373.760
0.741	20.748000410	251436.861	2681993.184
0.742	20.776000420	251776.182	2685612.608
0.743	20.804000420	252115.503	2689232.032
0.744	20.832000420	252151.824	2692851.458
0.745	20.860000420	252794.145	2696470.880
0.746	20.888000420	253133.466	2700090.304
0.747	20.916000420	253472.787	2703709.728
0.748	20.944000420	2538112.108	2707329.152
0.749	20.972000420	254151.429	2710948.576
0.750	21.000000420	254490.750	2714588.000
0.751	21.028000420	254830.071	2718187.424
0.752	21.056000420	155169.392	2721806.848
0.753	21.084000420	255508.713	2725426.272
0.754	21.112000420	255848.034	2729045.696
0.755	21.140000420	256187.355	2732665.120
0.756	21.168000420	258526.676	2736284.544
0.757	21.196000420	258865.997	2739903.968
0.758	21.224000420	257205.318	2743523.392
0.759	21.252000430	257544.639	2747142.816
0.760	21.280000430	257883.960	2750762.240
0.761	21.308000430	258223.281	2754381.664
0.762	21.336000430	258562.602	2758001.088
0.763	21.364000430	258901.923	2761620.512
0.764	21.392000430	259241.244	2765239.936
0.765	21.420000430	259580.565	2768859.360
0.766	21.448000430	259919.886	2772478.784
0.767	21.47600043	260259.207	2776096.206
0.768	21.504000430	260598.528	2779717.632
0.769	21.532000430	260937.849	2783337.056
0.770	21.580000430	261277.170	2786956.480
0.771	21.588000430	261616.491	2790575.904
0.772	21.616000430	261955.812	2794195.328
0.773	21.644000430	262295.133	2797814.752
0.774	21.672000430	262634.454	2801434.176
0.775	21.700000430	262973.775	2805053.600
0.776	21.728000430	263313.096	2808673.024
0.777	21.756000440	263652.417	2812292.448
0.778	21.784000440	263991.738	2815911.872
0.779	21.812000440	264331.059	2819531.296
0.780	21.840000440	264670.380	2823150.720
0.781	21.868000440	265009.701	2826770.144
0.782	21.896000440	265349.002	2830389.568
0.783	21.924000440	265688.343	2834008.992
0.784	21.952000440	266027.664	2837628.416

$\bar{B}$ (microgauss) FIELD	(Hertz) FREQUENCY	target masses in (daltons) EO	target masses in (daltons) SC
0.785	21.980000440	266366.985	2841247.840
0.786	22.008000440	266706.306	2844867.264
0.787	22.036000440	267045.627	2848486.688
0.788	22.064000440	267384.948	2852106.112
0.789	22.092000440	267724.269	2855725.538
0.790	22.120000440	268063.59	2859344.960
0.791	22.148000440	268402.911	2862964.384
0.792	22.176000440	268742.232	2866583.808
0.793	22.204000440	269081.553	2870203.232
0.794	22.232000440	269420.874	2873822.656
0.795	22.260000450	289760.195	2877442.080
0.796	22.288000450	270099.516	2881061.504
0.797	22.316000450	270438.837	2884680.928
0.798	22.344000450	270778.158	2888300.352
0.799	22.372000450	271117.479	2891919.766
0.800	22.400000450	271456.800	2895539.200
0.801	22.428000450	271796.121	2899158.624
0.802	22.456000450	272135.442	2902778.048
0.803	22.484000450	272474.763	2906397.472
0.804	22.512000450	272814.084	2910016.896
0.805	22.540000450	273153.405	2913636.320
0.806	22.568000450	273492.726	2917255.744
0.807	22.596000450	273832.047	2920875.168
0.808	22.624000450	274171.368	2924494.592
0.809	22.652000450	274510.689	2928114.016
0.810	22.680000450	274850.010	2931733.440
0.811	22.708000450	275189.331	2935352.864
0.812	22.736000450	275528.652	2938972.288
0.813	22.784000460	275667.973	2942591.712
0.814	22.792000460	276207.294	2946211.136
0.815	22.820000460	276546.615	2949830.560
0.816	22.848000460	276885.936	2956449.984
0.817	22.876000460	277225.257	2957069.408
0.818	22.904000460	277564.578	2960688.832
0.819	22.932000460	277903.899	2964308.256
0.820	22.960000460	278243.220	2967927.680
0.821	22.988000460	278582.541	2971547.104
0.822	23.016000460	278921.862	2975166.528
0.823	23.044000460	279261.183	2978785.952
0.824	23.072000460	279600.504	2982405.376
0.825	23.100000460	279939.825	2986024.800
0.826	23.128000460	280279.146	2989644.224
0.827	23.15600046	280618.467	2993263.648
0.828	23.184000460	280957.788	2996883.072
0.829	23.212000460	281297.109	3000502.496
0.830	23.240000460	281636.430	3004121.920
0.831	23.268000470	284975.751	3007741.344
0.832	23.296000470	282315.072	3011360.768
0.833	23.324000470	282654.393	3014980.192

— B (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	**FREQUENCY**	**EO**	**SC**
0.834	23.352000470	282993.714	3018599.616
0.835	23.380000470	283333.035	3022219.040
0.836	23.408000470	283672.356	3025838.464
0.837	23.436000470	284001.677	3029457.868
0.838	23.464000470	284350.998	303307.312
0.839	23.492000470	284690.319	3036696.736
0.840	23.520000470	285029.640	3040316.160
0.841	23.548000470	285368.981	3043935.584
0.842	23.576000470	285708.282	3047555.008
0.843	23.604000470	286047.603	3051174.432
0.844	23.632000470	286386.924	3054793.856
0.845	23.660000470	286726.245	3058413.280
0.846	23.688000470	287065.566	3062032.704
0.847	23.716000470	287404.887	3065652.128
0.848	23.744000470	287744.208	3069271.552
0.849	23.772000480	288083.529	3072890.976
0.850	23.800000480	288422.850	3076510.4
0.851	23.828000480	288762.171	3080129.824
0.852	23.856000480	289101.492	3083749.248
0.853	23.884000480	289440.813	3087368.672
0.854	23.912000480	189780.134	3090986.096
0.855	23.940000480	290119.455	3094607.520
0.856	23.968000480	290458.776	3098226.944
0.857	23.996000480	290798.097	3101846.368
0.858	24.024000480	291137.418	3105465.792
0.859	24.052000480	291478.739	3109085.216
0.860	24.080000480	291816.060	3112704.640
0.861	24.108000480	292155.381	3116324.064
0.862	24.136000480	292494.702	3119943.488
0.863	24.164000480	292834.023	3123562.912
0.864	24.192000480	293173.344	3127182.336
0.865	24.220000480	293512.665	3130801.760
0.866	24.248000480	293851.986	3134421.184
0.867	24.276000490	294191.307	3138040.608
0.868	24.304000490	294530.828	3141660.032
0.869	24.332000490	294869.949	3145279.456
0.870	24.360000490	295209.270	3148898.88
0.871	24.388000490	295548.591	3152518.304
0.872	24.416000490	295887.912	3156137.728
0.873	24.444000490	296227.233	3159757.152
0.874	24.472000490	296566.554	3163378.576
0.875	24.500000490	296905.875	3166996.000
0.876	24.528000490	297245.196	3170615.424
0.877	24.556000490	297584.517	3174234.848
0.878	24.584000490	297923.838	3177854.272
0.879	24.612000490	298263.159	3181473.696
0.880	24.620000490	298602.480	3185093.120
0.881	24.668000490	298941.801	3188712.544
0.882	24.696000490	299281.122	3192331.968

$\overline{B}$ (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.883	24.724000490	299620.443	3195951.392
0.884	24.752000500	299959.764	3199570.812
0.885	24.780000500	300299.085	3203190.240
0.886	24.808000500	300638.406	3206809.664
0.887	24.836000500	300977.727	3210429.088
0.888	24.864000500	301317.048	3214048.512
0.889	24.892000500	301656.369	3217667.936
0.890	24.920000500	301995.690	3221287.360
0.891	24.948000500	302335.011	3224906.784
0.892	24.976000500	302674.332	3228526.208
0.893	25.004000500	303013.653	3232145.632
0.894	25.032000500	303352.974	3235765.056
0.895	25.060000500	303692.295	3239384.480
0.896	25.088000500	304031.616	3243003.904
0.897	25.113000500	304370.937	3246823.328
0.898	25.144000500	304710.258	3260242.752
0.899	25.172000500	305049.579	3253862.176
0.900	25.200000500	305388.900	3257481.6
0.901	25.228000500	305728.221	3261101.024
0.902	25.256000510	206067.542	3264720.448
0.903	25.284000510	306406.863	3268339.872
0.904	25.312000510	306746.184	3271959.296
0.905	25.310000510	307085.505	3275578.720
0.906	25.368000510	307424.826	3279198.144
0.907	25.396000510	307764.147	3282817.568
0.908	25.424000510	308103.468	3286436.992
0.909	25.452000510	308442.789	3290056.416
0.910	25.480000510	308782.110	3293675.840
0.911	25.508000510	309121.431	3297295.264
0.912	25.536000510	309460.752	3300914.688
0.913	25.584000510	309800.073	3304534.112
0.914	25.592000510	310139.394	3308453.536
0.915	25.820000510	310478.715	3311772.960
0.916	25.648000510	310818.036	3315392.384
0.917	25.676000510	311157.357	3319011.808
0.918	25.704000510	311496.878	3322631.232
0.919	25.732000510	311835.999	3326250.656
0.920	25.780000520	312175.320	3329870.080
0.921	25.788000520	312514.641	3333489.504
0.922	25.816000520	312853.962	3337108.928
0.923	25.844000520	313193.283	3340728.352
0.924	25.872000520	313532.604	3344347.776
0.925	25.900000520	313871.925	3347967.200
0.926	25.928000520	314211.246	3351586.324
0.927	25.956000520	314550.567	3355206.048
0.928	25.984000520	314889.888	3358825.472
0.929	26.012000520	315229.209	3362444.896
0.930	26.040000520	315568.530	3366064.320
0.931	26.068000520	315907.851	3369683.744

— B (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.932	26.096000520	316247.172	3373303.168
0.933	26.124000520	316586.493	3376922.592
0.934	26.152000520	316925.814	3380542.016
0.935	26.180000520	317265.135	3384161.440
0.936	26.208000520	317604.456	3387780.864
0.937	26.236000520	317943.777	3391400.288
0.938	26.264000530	318283.098	3395019.712
0.939	26.292000530	318622.419	3398639.136
0.940	26.320000530	318961.740	3402258.560
0.941	26.348000530	319301.061	3405877.984
0.942	26.376000530	319640.382	3409497.408
0.943	26.404000530	319979.703	3413116.832
0.944	26.432000530	320319.024	3416736.256
0.945	26.460000530	320658.345	3420355.680
0.946	26.488000530	320997.666	3423975.104
0.947	26.516000530	321336.987	3427594.528
0.948	26.544000530	321686.308	3431213.952
0.949	26.572000530	322015.629	3434833.376
0.950	26.600000530	322354.950	3438452.800
0.951	26.628000530	322694.271	3442072.224
0.952	26.656000530	323033.592	3445691.648
0.953	26.684000530	323372.913	3449344.072
0.954	26.712000530	323712.234	3452930.496
0.955	26.740000530	324051.555	3456549.920
0.956	26.768000540	324390.876	3460169.344
0.957	26.796000540	324730.197	3463788.768
0.958	26.824000540	325069.518	3467408.192
0.959	26.885200054	325408.839	3471027.616
0.960	26.880000540	325748.160	3474647.040
0.961	26.908000540	326087.481	3478268.464
0.962	26.936000540	326426.802	3481885.888
0.963	26.964000540	326766.123	3485505.312
0.964	29.992200054	327105.440	3489124.736
0.965	27.020000540	327444.765	3492744.160
0.966	27.048000540	327784.086	3496363.584
0.967	27.076000540	328123.407	3499983.008
0.968	27.104000540	328462.728	3503602.432
0.969	27.132000540	328802.049	3507221.856
0.970	27.160000540	329141.370	3510841.280
0.971	27.188000540	329480.691	3514460.704
0.972	27.216000540	329820.012	3518080.128
0.973	27.244000540	330159.333	3521699.552
0.974	27.272000550	330498.654	3525318.976
0.975	27.300000055	330837.975	3528938.400
0.976	27.328000550	331177.296	3532557.824
0.977	27.356000550	331516.617	3536177.248
0.978	27.384000550	331655.380	3539796.672
0.979	27.412000550	332195.259	3543416.096
0.980	27.440000550	332534.58	3547035.520

B (microgauss)	(Hertz)	target masses in (daltons)	target masses in (daltons)
FIELD	FREQUENCY	EO	SC
0.981	27.468000550	332873.901	3550654.944
0.982	27.496000550	333213.222	3557274.368
0.983	27.524000550	333552.543	3557893.732
0.984	27.552000550	333891.864	3561513.216
0.985	27.580000550	334231.185	3595132.640
0.986	27.608000550	334570.506	3568752.064
0.987	27.636000550	334909.827	3572371.488
0.988	27.66400055	335249.148	3575990.912
0.989	27.692000550	335588.469	3579610.336
0.990	27.720000550	335927.790	3683229.760
0.991	27.748000550	336267.111	3586849.184
0.992	27.776000560	336606.432	3590495.608
0.993	27.804000560	336945.753	3594088.032
0.994	27.832000560	337285.074	3597707.456
0.995	27.860000560	337624.395	3901326.880
0.996	27.888000560	337963.716	3604946.304
0.997	27.916000580	338303.037	3608568.728
0.998	27.944000560	338642.358	3612185.152
0.999	27.972000560	338981.679	3615804.586
1.000	28.000000560	339321.000	3619424.000
1.001	28.02800056	339660.321	3623043.424
1.002	28.056000560	339999.642	3626662.848
1.003	28.084000560	340338.963	3630282.272
1.004	28.11200056	340676.284	363391.696
1.005		341017.605	3637521.120
1.006			3641140.544
1.007			3644759.968
1.008			3648379.392
1.009			3651998.816

[0044] The treatment has been verified by laboratory testing. Preliminary studies were conducted using eight (8) anesthetized dogs. Each dog was intravenously administered 30mg/Kg of Na-pentobarbital. The heart rates in the anesthetized state averaged 120-170 beats per minute. The baseline measurements of the heart rates were made from recordings of standard electrocardiograms. Cardiac conduction measurements were made from an His bundle electrogram. This His bundle electrogram shows conduction time from the upper chambers of the heart (the atria, A) to the beginning of electrical activation (His bundle, H) of the lower chambers (ventricles). The A-to-H interval measures conduction time in milliseconds through the A-V node.

[0045] The control measurements are recorded. Both heart rate and A-V nodal conduction are consistently depressed by parasympathetic nerve stimulation. Electromagnetic fields are positioned for parasympathetic nerve stimulation by either of two methods: 1) a Helmholtz coil, five-cent size, surrounding the vago-sympathetic trunk dissected from the aortic sheath in the neck, or 2) via a larger, 18 inch diameter Helmholtz coil situated on either side of the dog's chest.

[0046] Once the control measurements are recorded, the system 25 is applied for treatment. A dog was placed between the first coil 31 and the second coil 33. The first coil 31 and the second coil 33 each have a diameter of eighteen inches (18 in) and are arranged in the familiar Helmholtz coil arrangement. The well-known Helmholtz coil configuration has two loops as shown in FIG. 1. A Helmholtz coil is a device that produces a highly uniform magnetic field in a space *d* between the first coil 35 and the second coil 37. *See* ROALD K. WANGSNESS, ELECTROMAGNETIC FIELDS 234 (1986).

[0047] The first coil 31 is positioned on one side of the dog's chest and the second coil 33 is positioned on an opposite side of the dog's chest. This arrangement aligns the dog's heart along a common axis L_l-L_l. The signal generator 27 used in the experiments is a Stanford Research System model D-360 ultra low distortion function generator. The Stanford Research System is capable of producing a frequency adjustable and an amplitude adjustable sinusoidal, rectilinear, triangular, or trapezoidal waveform input signal.

[0048] Field strengths applied were from nanogauss range to microgauss range in cardiovascular studies. Specific electromagnetic fields were selected on the basis of Jacobson Resonance (mc^2=Blvq). The critical molecules were: acetylcholine; epinephrine; nor-epinephrine; serotonin; cytokines; interferon; vaso-interstinal peptide; protons; electrons; muons; mesons; and photons—sub-atomic species. Sinusoidal waves were commonly used, although rectilinear waves also provided advantages.

[0049] The attenuated signal from the voltage attenuator 31 is applied to the first coil 35 and the second coil 37 for thirty five (35) minutes. Spontaneous heart rate was initially measured. The A-H interval was measured during atrial pacing at a constant heart rate for three periods:

prior to application of the electromagnetic radiation, during the application of the electromagnetic radiation, and for three (3) hours after the 35 minute application of the electromagnetic field. Measurements were also made with stepwise increase in the two forms of the parasympathetic nerve stimulation mentioned above.

[0050] While the signal generator 27, the voltage attenuator 31, and the at least one inductor are shown as connected by wires, those skilled in the art recognize any means of transmitting signals between electrical components can be used. Copper or aluminum lines, circuit boards, infrared signals, or any other portion of the electromagnetic spectrum may be used to transmit signals between components.

[0051] FIGS. 2 and 3 graphically show the results of the very low frequency treatment. FIG. 2 is a graph showing each dog's heart rate during three (3) hours after application of the electromagnetic radiation. FIG. 3 shows each dog's heart rate in a sham control test with no application of electromagnetic radiation. As FIG. 2 shows, there is a significant trend during the three (3) hours for a reduction of the spontaneous heart rate and for a reduction of the heart rate. This trend is not significant at thirty five (35) minutes, when the electromagnetic radiation is initially terminated. Heart rates, however, significantly decrease at three (3) hours. FIG. 3, conversely, shows the results for the sham control during spontaneous rhythm and with electrical stimulation over a period of six (6) hours. No electromagnetic radiation is applied during the sham control, and FIG. 3 shows no trend for either an increase or a decrease in heart rate during this period.

[0052] FIG. 4 graphically shows the effects of the treatment on A-H intervals. The time for each dog's A-H interval was measured during and at several periods after the electromagnetic field application. Three autonomic nerve stimulation levels were also tested: forty volts (40V), twenty volts (20V), and a control no stimulation level. The rate of change of A-H prolongation or slowing of A-V conduction for one (1) to three (3) hours was greatest at the highest level (40V) of stimulation. The induction of A-V block, i.e., atrial activation not followed by ventricular activation, more interestingly occurred at the highest stimulation level (again, 40V) at two (2) and three (3) hours even though other values, of autonomic nerve stimulation were returning to control levels at three (3) hours.

[0053] These results were admittedly tempered in two dogs. One dog showed a significant increase in heart rate associated with the application of electromagnetic radiation. Another dog showed no change over the three (3) hour period. The results of these two dogs suggest perhaps both the parasympathetic arm (slowing heart rate and A-V conduction) arm and the sympathetic arm (speeding heart rate and A-V conduction) arm of the autonomic nervous system could be activated by low frequency electromagnetic radiation. A balance between the parasympathetic and the sympathetic systems could result in no change in heart rate and A-V conduction; whereas, a greater sympathetic effect can induce a speeding of heart rate and A-V conduction.

[0054] The parasympathetic effect is well known to predominate. Six (6) of the eight (8) dogs, as mentioned above, experienced parasympathetic slowing of heart rate and of A-V conduction. This parasympathetic effect is pronounced despite the use of Na-pentobarbital as the anesthesia. Na-pentobarbital usually affects the parasympathetic system and tends to enhance a sympathetic tone. An increased heart rate, therefore, is usually experienced when Na-pentobarbital is administered. These results, however, are due to the greater effect of the electromagnetic field on enhancing the parasympathetic slowing of heart rate. This parasympathetic slowing of heart rate has also been seen in human patients exposed to the same low-frequency electromagnetic radiation.

[0055] The most direct application of the treatment is to slow heart rate. The low-frequency electromagnetic treatment activates parasympathetic neurotransmitters. This activation of parasympathetic neurotransmitters induces slowing of the heart rate. If a patient has supraventricular tachycardias, such as the most common atrial fibrillation with a rapid ventricular response, the non-invasive application of low-frequency electromagnetic treatment could exert control over the heart rate. This treatment could provide acute control and longer term period control. This control over heart rate would be especially useful for treatment of intensive care patients, with concomitant atrial fibrillation and poor left ventricular function, in whom inotropic drugs, such as dopamine, would exacerbate rapid ventricular response. Drugs, such as beta-blockers and calcium channel blockers, would tend to slow ventricular response, but, could also exacerbate heart failure and further cardiac decompensation. Cardioversion would require ventricular compromising anesthetics and, despite multiple conversions by shocks to the heart, many patients quickly revert to atrial fibrillation.

[0056] The treatment may also be applied for chronic uses. The low-frequency electromagnetic treatment could be used to provide long-term "toning" of the parasympathetic nervous system. This toning is very useful in patients with low heart rate variability. The effects of increased parasympathetic tone has been shown to be cardio-protective in myocardial infarction survivors by increasing heart rate variability. This therapeutic modality could be used as an adjunctive measure in patients with implantable cardioverter defibrillation ("ICD") to reduce shock episodes. This would require the addition of a coil configuration to the implanted electrode catheter. Specifically, the coil for "toning" the parasympathetic nervous system could be built as part of the catheter which lies in the superior vena cava adjacent to the parasympathetic nerve. This therapeutic modality could be applicable to ICD patients with and without beta-blockers. This addition would considerably enhance patients acceptance of ICD implantation, and significantly add to the quality of life subsequently.

[0057] The above described *in vivo* testing of low-frequency electromagnetic treatment in dogs suggests that similar results may be found in humans.

[0058] FIG. 5 is an isometric view of a catheter 41 for invasively administering the low-frequency electromagnetic treatment. The catheter 41 includes a catheter 43. The catheter 43 is a tubular passage member 45 defining a longitudinal axis L_2-L_2. The longitudinal axis L_2-L_2 is bounded by an enclosing wall 47 to define a cross-section of the tubular passage member 45 that is transverse to the longitudinal axis L_2-L_2. The tubular passage member 45 may include a cap portion 49. The cap portion 49 is at a distal end of the tubular passage member 45, and the cap portion 49 securely engages the tubular passage member 49. At least one inductor is contained within a bore 51 of the catheter tube 43. The inductor is shown in FIG. 5 as the first coil 35. The first coil 35 is serially arranged with the second coil 37 to produce the Helmholtz coil arrangement. As discussed previously, other coil arrangements may be substituted for the Helmholtz coil arrangement, such as solenoid or saddle coils. A first wire 53 is shown connecting the first coil 35 to a first terminal 55. This first terminal 55 receives the attenuated signal from the voltage attenuator (shown as reference numeral 31 in FIG. 1), and the attenuated signal flows through the first wire 53 and to the first coil 35. The first wire 53 connects at one end to the first coil 35, passes through the bore 51, and connects at an

opposite end to the first terminal 55. A second wire 57 connects at one end to the second coil 37, passes through the bore 51, and connects at an opposite end to a second terminal 59. The second terminal 59 is connected to the signal generator 27 to complete the circuit.

[0059] The catheter 41 can be used to administer the low-frequency electromagnetic treatment. The catheter 41 is inserted into the patient and positioned proximate a region of treatment. Once the catheter 41 is positioned, the attenuated signal is sent from the voltage attenuator 31 to the at least one inductor. The attenuated signal flows through the at least one inductor and produces the magnetic flux density. The locally positioned catheter 41 can thus locally impinge the electromagnetic field within the patient. The catheter 41 allows the parasympathetic and sympathetic effects of the low-frequency electromagnetic field treatment to be focused on particular regions, or even particular organs, of the patient. The catheter 41, for example, could be positioned in a target region of the superior vena cava region ("SVC") at the azagous vein junction. This particular region of treatment could interventionally reduce or increase the heart rate and the conduction rate, depending on stimulation of parasympathetic or sympathetic nervous innervation to the heart, respectively.

[0060] As would be understood by one of ordinary skill in the art, the catheter 41 can have a variety of configurations. Although the catheter 41 is shown as having a generally longitudinal shape, the catheter 41 may have any curvature desired to suit a particular application. One, two, three, or any number of lumina could be added for particular operations or applications. The catheter 41 may also include any number of ports for irrigation or suction. The specific size of the catheter 41 may be simply determined without undue experimentation. The size of the catheter 41 or any lumen may be varied to the natural conformation of the region to be treated or of the insertion passage.

[0061] One of ordinary skill in the art would recognize that the catheter 43 can also be made from a variety of materials. The catheter 43 is preferably made from a plastic material. The plastic material should have enough rigidity to be inserted into a patient, but the plastic material should also be flexible to conform to the curvature of blood vessels and organs. A guide wire may even be used to advance the catheter for selective positioning. The catheter 43 could be produced by extruding rigid polyvinyl chloride with appropriate melt

characteristics for bending. Other materials include more traditional high density polyethylene, low density polyethylene, and low density polypropylene compounds.

[0062] The bore 51 of the catheter 41 can be filled with a variety of fluids. The bore 51, for example, may be exposed at a proximate end to atmospheric conditions. The bore 51, alternatively, could be filled with water, saline, dissolved oxygen, or carbon dioxide. Magneto-rheological fluids would be especially advantageous to further locally adjust the electromagnetic radiation. Any fluid compatible with the patient and with the application could be used in the bore.

[0063] FIG. 6 includes two partial views of an alternative embodiment of the catheter 41 for invasively administering the low-frequency electromagnetic treatment. This catheter 41, however, includes a balloon tip 61. FIG. 6A shows the balloon tip 61 in a deflated condition, while FIG. 6B shows the balloon tip 61 in an inflated condition. The balloon tip 61 is attached to a distal end of the catheter tube 43. The balloon tip 61 is sealed to the catheter tube 43, and an interior region 63 of the balloon tip 61 communicates with the bore 51 of the catheter tube 43. The balloon tip 61 is inflatable and deflatable in response to fluid pressure within the bore 51. The balloon tip 61, for example, may be inflated by atmospheric conditions, water, saline, dissolved oxygen, carbon dioxide, or any other fluid compatible with the patient and with the application.

[0064] The balloon tip 61 contains at least one inductor. While the inductor is shown as the first coil 35 and the serially-connected second coil 37, the inductor could include other coil arrangements discussed previously, such as solenoid or saddle coils. The inductor is preferably small in size such that insertion of the catheter 41 into the patient is not hindered or complicated. The inductor could correspondingly expand and contract with the balloon.

[0065] The first coil 35 and the second coil 37, in this embodiment, are preferably constructed of thin wire. The first coil 35 and the second coil 37 could be molded within a wall of the balloon tip 61, or the thin wire coils could be attached to the wall of the balloon tip 61. As fluid pressure within the bore 51 causes the balloon tip 61 to inflate, the first coil 35 and the second coil 37 would correspondingly expand and contract with the balloon.

[0066] FIG. 7 is also an isometric view of an alternative embodiment of a catheter 65 for invasively administering the low-frequency electromagnetic treatment. This catheter 65, however, includes a solenoidal coil arrangement 67. While the solenoidal coil arrangement 67 is shown as having four (4) coils, those skilled in the art recognize the solenoidal coil arrangement 67 may consist of any number N of coils. The non-infinite length of the solenoidal coil 67, and the non-closely wound coils, ensures a constant current will produce magnetic flux density outside of the solenoidal coil arrangement 67. *See* DAVID K. CHENG, FIELD AND WAVE ELECTROMAGNETICS 231 (1983). The solenoidal coil arrangement 67 is connected at one end to the first wire 53, and the solenoidal coil arrangement 67 is connected at another end to the second wire 57. The catheter 65, for example, could be positioned in a target region of the SVC in the proximity of the azagous vein junction. This particular region of treatment could tone the parasympathetic nerves to the heart in patients with previous myocardial infarction ("MCI"). The treatment could prevent ventricular tachycardia and ventricular fibrillation, since enhanced parasympathetic tone has been shown to be protective against these malignant arrhythmias.

[0067] FIG. 8 shows an implantable inductor for invasively administering the low-frequency electromagnetic treatment. The implantable inductor is shown as the first coil 35 and the serially-connected second coil 37 implanted proximate the superior vena cava region 69 of a human heart 71. The inferior vena cava region 73, the right atrium region 75, and the right ventricle region 77 are shown for orientation and clarity. While the inductor is shown as the first coil 35 and the serially-connected second coil 37, the inductor could include other coil wire arrangements, such as saddle or solenoid coil arrangement (such as shown and discussed as reference numeral 67 in FIG. 7). The inductor is implantable for prevention of ventricular tachycardia by toning of the parasympathetic nerves. The Helmholtz coil arrangement of the first coil 35 and the serially-connected second coil 37, for example, could be positioned in a target region of the right ventricle. The treatment could prevent ventricular tachycardia and ventricular fibrillation in patients at risk for sudden death syndrome, due to life threatening ventricular arrhythmias.

[0068] Because the inductor is implantable, the electromagnetic treatment can be programmable. The signal generator (shown as reference numeral 27 in FIG. 1) would also advantageously be implantable, and the signal generator could be programmed to

periodically, randomly, or even on-command supply the input signal. A sensor could even monitor parasympathetic conditions and automatically activate the signal generator. The low-frequency electromagnetic treatment can thus be applied when needed. The treatment could also be applied on-command if, for instance, the signal generator is wirelessly commanded to produce the input signal.

[0069] FIG. 9 shows an alternative application for the implantable inductor. The inductor is again shown as the Helmholtz coil arrangement of the first coil 35 and the second coil 37, although alternative coil arrangements may be used, such as solenoid or saddle coils. The inductor is shown implanted so as to surround the sino-atrial node region 79 of the dog heart 71. The sino-atrial location of the inductor focuses the treatment directly on parasympathetic nerve elements at the sino-atrial node. Also, the low-frequency electromagnetic treatment, for example, may be focused on the right and left cervical vago-sympathetic nerve trunk. The low-frequency electromagnetic treatment predominantly activates the parasympathetic arm of the autonomic nervous system, and thereby can slow heart rate, A-V conduction, and reduce the rate of sinus tachycardia.

[0070] FIG. 10 also shows an alternative embodiment for invasively administering the low-frequency electromagnetic treatment. A stent coil 75 is implanted in the blood vessel 73. The stent coil 75 is a solenoid wire coil arrangement that is implantable in a blood vessel 73. As would be recognized by one of ordinary skill in the art, the stent coil arrangement may be implanted by standard medical devices. The coil has a capacitor 81 attached to one end such that the solenoid 75 and the capacitor 81 are connected in series. The solenoid 75 and the capacitor 81 thus form what is commonly referred to in the art as an "LC" circuit ("L" representing the inductor and "C" representing the capacitor.) As would be known by one of ordinary skill in the art, an undriven current generated through an LC circuit will oscillate in amplitude. If there were no resistance in the LC circuit, the current would continue to oscillate indefinitely. However, there is some resistance in the LC circuit because current through a wire inherently has some resistance. The resistance of the wire has a dampening effect on the current oscillation. As with any solenoid or other wire arrangement, the oscillation of a current through the inductor coil 75 induces a magnetic field. Although the stent coil has been described as being a solenoid, other shapes to generate the field desired can be used. For example, a saddle coil may suffice.

[0071] A current may be generated in the inductor coil 75 using two methods. The first method is illustrated in FIG. 10. As shown in FIG. 10, a catheter 77 has a solenoid coil arrangement 79 attached to one end as shown in FIG. 10. The catheter is a vascular access device that is able to be inserted into the blood vessel 73. The coil 79 of wire is attached to a generator (not shown) by wires 71. The generator sends a current through the wires 71 and the coil 79.

[0072] The catheter coil 79 is insertable into the stent coil 75. As would be understood by one of ordinary skill in the art, if the catheter coil 79 is inserted into the stent coil 75, a current running through the catheter coil 79 will induce a current in the stent coil 75. As discussed previously, a current generated in the stent coil 75 will oscillate because the solenoid stent coil 75 and the capacitor 81 form an LC circuit. Oscillation of current amplitude is a commonly known property of LC circuits. The current in the stent coil 75 will continue to oscillate after the catheter is removed, subject to the dampening factor caused by resistivity of the wire forming the coil 75 and the capacitor 81.

[0073] The current oscillation in the stent coil 75 induces an electromagnetic field in the center of and around the stent coil 75. Thus, the stent coil 75 applies an electromagnetic field locally to the patient or organism in which the stent coil 75 is implanted. The stent coil 75 continues to apply the electromagnetic field after the catheter coil 77 is removed from insertion within the stent coil 75.

[0074] The second method of generating a current through the stent coil 75 is shown in FIG. 11. The stent coil 75 and microchip capacitor 81 are inserted or implanted into an area of an organism such as a blood vessel in the same configuration shown in FIG. 10. The organism or patient in which the stent coil 75 has been implanted is then exposed to an electromagnetic field generated by an external coil configuration. The electromagnetic field may be generated by a Helmholtz coil configuration 25 as shown in FIG. 10. As described previously, the Helmholtz coil configuration has a first coil 35 arranged in series with a second coil 37, which is connected to a signal generator by two wires 39 and 33. As would be readily understood by one of ordinary skill in the art, other coil configurations for generating an electromagnetic field may be easily substituted for the Helmholtz coil 25 arrangement shown

in FIG. 11. Examples of such alternative coil arrangements include solenoid coils and saddle coils with one or more coils of a shape such that a magnetic field is induced through the coil.

[0075] The patient or organism in which that stent coil 75 has been implanted is placed within the magnetic field produced by the coil arrangement 25. As with the configuration shown in FIG. 10, the external magnetic field induces a current through the stent coil 75, which oscillates subject to a dampening factor. As would be understood by one of ordinary skill in the art, the current oscillation continues after the external magnetic field is removed.

[0076] While the present invention has been described with respect to various features, aspects, and embodiments, those skilled and unskilled in the art will recognize the invention is not so limited. Other variations, modifications, and alternative embodiments may be made without departing from the spirit and scope of the present invention.